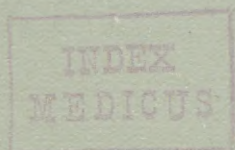
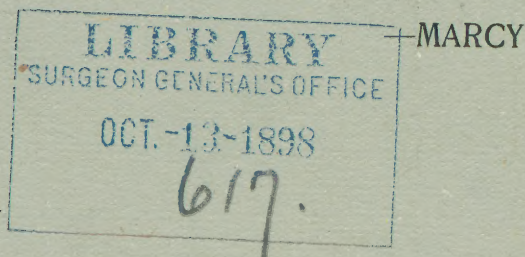


MARCY (H.O.)

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THE ASEPTIC ANIMAL SUTURE:  
ITS PLACE IN SURGERY





# The Aseptic Animal Suture: Its Place in Surgery.

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BY HENRY O. MARCY, A.M., M.D., LL.D.

BOSTON, U. S. A.

Surgeon to the Cambridge Hospital for Women; late President of the American Medical Association; President of the Section on Gynecology, Ninth International Medical Congress; late President of the American Academy of Medicine; Member of the British Medical Association; Member of the Massachusetts Medical Society; Member of the Boston Gynecological Society; Corresponding Member of the Medico-Chirurgical Society of Bologna, Italy;  
late Surgeon U. S. A., etc.

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# THE ASEPTIC ANIMAL SUTURE: ITS PLACE IN SURGERY.

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BY HENRY O. MARCY, M.D., A.M., LL.D.

BOSTON, MASS.

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Modern surgical technic differs in such a marked degree from the methods of even a recent period, that it is not a wonder that great differences of opinion still exist in regard to many questions pertaining to the treatment of wounds. For the present, at least, certain conditions of fundamental type may be accepted as settled, so far as the theory, or ideal, aimed at is concerned; for example, a wound made in aseptic, well-vitalized tissues, and maintained aseptic will be followed by primary union. It is not my present purpose to discuss the methods for maintaining a wound aseptic only so far as pertains to its closure and subsequent protection.

In any considerable wound it is necessary to occlude blood vessels and rejoin the separated structures. This must be done by the use of ligatures and sutures. The material best adapted for this purpose is the subject of the present inquiry. The materials in use are, thread made from hemp, linen or silk, almost exclusively the latter; metallic sutures, iron, gold and silver; silkworm-gut, catgut, and the tendon of animals, especially that from the tail of the kangaroo.

The silk fiber, spun, twisted or braided in various sizes, is so manifestly superior to the vegetable fibers of cotton, hemp and linen, that only silk merits discussion. Silk has continued in more general use as a ligature for the following reasons: It is strong, is manufactured into a thread that is very smooth and even, can be readily sterilized by wet and dry heat, is comparatively cheap and easily obtained in any desired size. Until it was found possible to close and seal wounds without drainage, silk seemed the ideal material for ligatures and sutures. Then it was supposed necessary to remove both ligatures and sutures,

no matter how applied. When it was shown to be unnecessary and even harmful to drain aseptic wounds, the inquiry naturally arose, can not some material be found for sutures which will remain in the tissues sufficiently long to serve the purpose of constriction or coaptation, and ultimately disappear under the influences of the vital processes of the surrounding structures?

So far as the ligation of the larger arteries is concerned the problem thus presented is by no means new. The most important of the original studies in this direction of an early type were conducted by Dr. H. G. Jameson of Baltimore, and his prize essay published in 1829, upon the closure of arteries in continuity by the use of the animal ligature is worthy of commendation as a contribution of the highest scientific importance. It is singular to note that many of the leading surgeons of this period accepted his teachings as of great value, and ligated arteries as Dr. Jameson directed, using for material, more commonly, carefully prepared strips of buckskin. These were experimented with, somewhat, by English surgeons and met the approval of even Sir Astley Cooper. The directions were explicit, to ligate so as to occlude, but not to devitalize the artery, cut short and leave the ligature in the deep part of the wound.

The list of experimental studies published by Dr. Jameson demonstrated that the result of such ligation in the calf, dog and sheep caused a permanent occlusion of the artery, that the foreign material was encapsulated by living cells, and that ultimately the ligature entirely disappeared, leaving in its place a permanent reinforcement of connective tissue.

However, all this valuable experience was lost and forgotten in the heated controversy over the so-called inflammatory processes in wounds, which promised a fruitless and endless discussion, until the masterly studies of Lord Lister demonstrated the cause of the same to be vital and extraneous. He naturally arrived at the theoretic conclusion that, in a non-infected



wound, the vital processes would be ample to permit of the safe application of an absorbable ligature for the constriction of an artery. So far as I know, Mr. Lister was utterly ignorant of the demonstrations of Dr. Jameson referred to above, and as the laws of England at that time were so framed that studies upon the lower animals, even of such an important character, were not permitted, this great master was obliged to resort to France for the privilege of pursuing his investigations. His conclusions are almost identical with those of Dr. Jameson. He used for ligature material, however, catgut as furnished for musical instruments, steeping it in a strong carbolic solution in order to render it antiseptic.

So far as I am aware it had not occurred to any to make use of sutures deeply implanted in wounds, *buried*, until in 1870, when it became very evident to me that it was necessary for the purpose of curing hernia to close separately the different structures of the abdominal wall and to restore the inguinal canal to its normal oblique direction.

Based upon the knowledge of the animal ligature left *in situ* about an artery, it seemed a logical deduction that this could be safely effected. I instituted at once a series of comparative studies in order to ascertain if such suturing was safe and trustworthy. My investigations proved conclusively that aseptic animal structures buried in well-vitalized tissues were surrounded by leucocytes, which, little by little, invaded the material used and *pari-passu* were themselves transformed into connective tissue-cells, taking in a considerable degree the shape and direction of the suture material. So noteworthy was this, that at first I was constrained to believe that the material itself became revitalized as a sort of graft, but more careful observations demonstrated that the foreign material disappeared by a process of absorption, leaving in its place a vitalized band of connective tissue, the resulting product of which, in certain conditions, proves to be of the greatest value, to-wit, where the

integrity of the parts are liable to damage because of tension, e. g., as in hernia and all wounded structures subject to special mobility. It gradually became evident that a careful coaptation of wounded tissues could be safely made, thus avoiding pockets of blood or serum, and, as a consequence, do away with the use of drainage-tubes, then supposed absolutely essential.

The drainage-tube in *aseptic* wounds can be only a damage and used as the least of two evils, since so much of the wound as is occupied by the tube must necessarily be left open, and closed by processes of a much slower character, so-called secondary union. Again, too, it was soon demonstrated that, notwithstanding the extraordinary precautions taken in the use of antiseptic dressings, a considerable percentage of wounds in which the drainage-tube was used, although aseptic so far as operative measures were concerned, became septic from the introduction of infection along the canal of the drainage-tube, more commonly due to the ever-present bacteria pertaining to the skin.

One of the most interesting and profitable original studies made in the Johns Hopkins Hospital was the demonstration of the micrococcus pyogenes albus as the normal habitant of the dying epithelium of the skin and their causation of so-called stitch abscesses, when the suture included the skin. Now the deduction seemed clear that an aseptic wound to remain aseptic must be coaptated so that pockets can not develop for the undue accumulation of fluids; that the drainage-tube should be abandoned, and that even the skin itself should be closed by a sub-cuticular suture in order to avoid skin infection. Then it was apparent that in the devising of the sub-cuticular suture in order to avoid stitch abscesses I had acted wiser than I then knew, and that the ideal dressing should consist of an hermetic seal so absolute as to prevent the possibility of extraneous infection. This is found in collodion, the contractile preferred, to which is added a small percentage of iodoform, reinforced by a few



fibers of absorbent cotton, which admirably accomplishes the purpose while it still further fixes and holds at rest the evenly coapted edges of the skin and minimizes the cicatricial line of repair. Oftentimes a cicatrix is traced with difficulty some weeks after the union of such a wound, a result, which upon certain parts of the body, for esthetic purposes is of the highest importance. Having worked out, by slow process of detail, the above conclusions and published<sup>1</sup> the results from time to time, I now thought it was of the first importance to demonstrate the kind of suture material best adapted for this purpose, viz., buried sutures.

*Material.*—Silk is manifestly unfitted, since, to say the least, when aseptically implanted in the tissues, it rarely, if ever, disappears by a process of absorption, and not seldom after a long period of discomfort, the structures rid themselves of it, attended with a considerable amount of suffering, with injury to the surrounding parts.

When silk sutures are buried, it is unquestionably better that the thread should be as fine as can be used with advantage. The sutures should be interrupted and few in number. Even thus carefully applied, it often happens that weeks or months afterward these sutures are thrown off by a process of proliferation, although the wound has been made and maintained aseptic.

Silk buried in portions of the body called into special activity is most likely to give trouble. So well established are the foregoing objections to buried silk sutures that a general inquiry has arisen, is it not possible to substitute something better in its place? Although metallic sutures were at one time in very

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<sup>1</sup> A New Use of Carbolized Catgut Ligatures, Applied for the Cure of Hernia. Henry O. Marcy, M.D., Boston Med. Surg. Journal, November, 1871, p. 315.

The Radical Cure of Hernia by the Use of Carbolized Catgut Ligatures. Trans. Amer. Med. Association, Vol. 29, pp. 295-305, 1878.

Animal Ligatures, Annals of Anatomy and Surgery, 1881, p. 282.

The Animal Suture, New England Medical Monthly, June 15, 1883.

The Surgical Advantages of the Buried Animal Suture, Journal of the American Medical Association, July 2, 1885. Reprint.

general use, for manifest reasons they have been discarded, until now they are limited to a very narrow range of possibilities. (Where it is necessary to make a permanent fixation of the osseous structures, the wire suture has an advantage, and here it is intended to be permanently left. Even under these conditions, when cut short and buried beneath the soft tissues, wire is very likely to be a source of subsequent irritation.) Silk-worm gut is absorbable in such a slow degree that it can be classed as belonging to the non-absorbable material used for ligatures and sutures, and for this reason is almost as objectionable as wire. The use of wire and silk-worm gut as a buried suture has its advocates for the most part among those who do not feel that animal sutures have a durability sufficient to be trustworthy.

I am indebted to Dr. Charles P. Noble of Philadelphia for a recent reprint of an article entitled, "Remarks upon the Use of the Buried Permanent Suture in Abdominal Surgery," published December, 1896. In it he states, "the original and simple method of a through-and-through suture for the closure of the wound in celiotomy has been tried and found wanting, because of suppuration and subsequent hernia. That he has had no experience with the use of catgut or other absorbable material in the closure of the celiotomy wound, because of the unfortunate results reported from Germany." He quotes Winter, who reports 8 per cent. of hernias following the use of the buried catgut suture. He also refers to the experience of Dr. Schede of Hamburg, who has employed silver wire as a buried permanent suture in the closure of celiotomy wounds since May, 1887. He thinks the favorable opinion of Schede is borne out by the experience in the Johns Hopkins Hospital where silver wire has been in general use for a number of years, with a low percentage of suppuration and few subsequent removals of the buried sutures. He also refers to the experience of Dr. Edebohls of New York, who for a considerable period used silk-

worm gut as a buried suture in the closure of the abdominal wall. Dr. Edebohls reports that from 5 to 10 per cent. of all his sutures thus employed caused suppuration and were either discharged spontaneously or required removal in order to secure closure of the wound or suppurating sinuses. In his aseptic wounds where primary union had taken place, suppuration followed in some cases in a few weeks, in others after some months, and in one after two years and a half. On this account Dr. Edebohls now uses chromicised catgut instead of silk-worm gut.

Dr. Nobe's object in writing his article is to show that in his experience silk-worm gut has proved a safe and reliable means of closing celiotomy wounds. He states, "that he has closed two hundred and ninety-seven celiotomy wounds by the use of buried silk-worm gut sutures with only seven cases of suppuration and with satisfactory results in preventing hernia." He emphasizes the selection of fine gut which is boiled for half an hour before each operation. The sutures are not tied too tightly and the ends are cut as short as possible. He used catgut for the closure of the peritoneum, the fatty structures and the skin as a continuous suture.

Dr. William B. Coley of New York reports<sup>2</sup> in detail sixteen cases where silk, silk-worm gut and silver wire were used as buried sutures for the cure of hernia. In these not alone was the hernia not cured, but suppuration supervened, and the sutures had to be removed. Of the number, five were closed with silk-worm gut sutures. He reports from the recent work of Schimmellbusch, page 121: "It has more than once been observed that in primary closure of wounds by silk or silver wire, the ligature, at the beginning well imbedded in the tissues, after a long period of time becomes repelled and suppurates out. The imbedded silk or silver wire simply remains as a foreign body in the tissues, of which the organism endeavors to free itself as soon as a favorable oppor-

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<sup>2</sup> New York Medical Journal, Feb. 29, 1891.



tunity presents." He also reports: "In two hundred and fifty cases of hernia operations in which I have used kangaroo tendon for buried sutures I have not had a single instance of sinus formation, and the percentage of primary union has been ninety-six per cent." . . . "The ideal suture, then, would be one that would hold the parts in apposition for eight or ten weeks and then disappear by absorption. In kangaroo tendon we have these conditions perfectly fulfilled. There has never been observed at the Hospital for Ruptured and Crippled a single case of delayed healing sinus when tendon or absorbable suture was used. Unless those who use and advocate silk, silk-worm gut or silver wire in hernia operations are able to present some advantages to offset the serious disadvantages that have been demonstrated, I believe these non-absorbable sutures should be entirely abandoned."

Chance furnished me the opportunity of being Lord Lister's first American pupil, and so great was my enthusiasm for the master that I accepted unquestionably his teachings of the value of catgut as a ligature. I prepared my own catgut ligatures for some years, according to his directions, and they were undoubtedly aseptic. It was not long, however, before infection followed the use of commercial catgut suture material which was obtained from the most reliable sources. This led me to investigate anew with painstaking care the animal structures which might be better suited for this purpose. I soon ascertained that catgut is necessarily faulty for two reasons, first, as the connective tissue sheath of the small intestine of the sheep, it must necessarily be separated from the other coats of intestine by maceration. This is in reality a process of bacterial putrefaction. The connective tissue sheath being more resistant to the putrefactive bacteria, remains less injured by it, and as a consequence can be removed entire, but it is necessarily damaged by the processes involved. When thus separated and cleaned, although

appearing as a white sheath of uninjured connective tissue, it is everywhere teeming with bacteria, and the cement substance which holds the connective tissue cells in fixation has been damaged by their action and by the necessarily long-continued maceration. So far as I am able to learn, at this stage of the process in the manufacture of catgut no thought of the value of sterilization has been entertained and no effort made for its accomplishment. The second objection to catgut as a suture material is the disposition of the connective tissue fibers themselves. For the physiologic necessity of dilatation and contraction of the intestine these fibers cross each other in a direction oblique to its long axis. The intestinal sheath is divided into strips more or less narrow in order to produce the desired sizes. When wet, it is an elastic, flat band with irregular edges. This is twisted upon itself into a cord and dried and thus is manufactured the catgut of commerce (strings originally designed for musical instruments).

Such is the extraordinary strength of the connective tissue that even thus disposed, when dry, catgut is very strong, but every musician knows the great care he must exercise in keeping it dry and keyed to the proper tension point. When damp it soon becomes soft, elastic and unreliable. When catgut is compared with the connective tissue found in the tendons of animals, the illustration is not overdrawn to say that the differences are as great as would result from weaving silk into the finest fabric, cutting it diagonally into strips and twisting it for use as a fishing line. When dry, it is comparatively strong, but when wet, a soft, elastic, flat band takes the place of the well-made fishing line. The surgeon must remember that his buried suture is ever wet since it is immersed in the fluids of the body. This is the reason that catgut swells so extraordinarily upon being soaked, that knots in catgut are unreliable, and the yielding of the ligature may be sufficient to prevent the closure of the enclosed artery. In the tendons of animals the con-

nective tissue cells are disposed parallel to each other and held firmly in contact by the cement substance, which in the preparation of sutures should be injured as little as possible. Tendons should be taken from freshly killed animals and prepared so that infective decomposition never ensues. Their use as ligatures is not new. Paul Eve, the great surgeon of Tennessee, employed them in the ligation of vessels many years before Mr. Lister's study of the subject. He used the tendons of the deer, taken directly from the freshly killed animal.

However, the knowledge of the use of tendons for ligatures was unknown to me until after my first publications upon the subject. As the result of my investigation and research for good suture materials, I was so convinced of their superiority that I contributed a paper upon the subject at the International Congress held in London in 1881. Tendons from the whale, the broad fascia of the back of the buffalo and moose (Indian thread) proved of about the same value as the long tendons from the leg of the moose, deer and caribou. Although less fatty they were little to be preferred to the tendons from the domestic animals. Good ligatures are comparatively easy to obtain from these sources, but suture material must be smooth, even, strong, fine and for a continuous suture, of considerable length to be of service.

After a prolonged research, I found that the tendons from the tail of a medium-sized kangaroo furnished a material which possessed all these requisites. The entire family of marsupials have the psoas muscle divided into fasciculi, each of which has its independent tendon, extending to the very extremity of the tail. These lie parallel to each other and are easily separated. In the larger kangaroo these tendons are not infrequently thirty inches long, but entirely too large for sutures. Many of them will split readily, but are never as strong or satisfactory as the whole tendon from a smaller animal. Much the larger amount of kangaroo tendon shipped for com-



mercial purposes is naturally obtained from the larger species, since it is sold by the pound, and by far the greater portion of tendon in the market is consequently less valuable.

Good tendon is smooth, even, and of a tensile strength greater than silver wire of the same weight. It should be taken from freshly killed animals, quickly sun-dried, and kept dry during the period of shipment, and as a consequence, its sterilization is effected with much greater certainty and with less damage to the intercellular cement substance. The tendon from the variety called the Wallaby furnishes the best suture material, but so difficult is it to obtain first-class tendons, that out of a lot of one hundred and forty pounds recently sent me, scarcely twenty were of first quality.

*Preparation and sterilization of catgut*—The recognition of the advantages attendant upon the use of absorbable suture material has been so universal that a very great many different methods have been experimentally tried in order to furnish from catgut the so-called ideal suture. The very fact that so many different methods of preparation have been employed is an evidence that none of them have proved entirely satisfactory. Only recently Dr. Nicholas Senn<sup>3</sup> of Chicago, has given his experience in the preparation of catgut. He approves Hofmeister's method of preparing catgut by the use of formalin. With this the profession is already familiar. The catgut is rendered tense by winding it upon a glass plate and immersed from twelve to forty-eight hours in a 2 to 4 per cent. aqueous solution of formalin; then immersed in flowing water for twelve hours to free the gut of the formalin, boiled in water from fifteen to twenty minutes, hardened and preserved in absolute alcohol containing 5 per cent. of glycerin and 1/10 of 1 per cent. of bichlorid of mercury.

Dr. Senn modifies the foregoing method by preserving the formalin gut, after boiling it, in absolute

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<sup>3</sup> Journal of the American Medical Association, Dec. 12, 1896.

alcohol 950 parts, glycerin 50, finely pulverized iodoform 100 parts. He considers the iodoform of value as a mild antiseptic, and that it diminishes the amount of primary wound secretion. He speaks of it only as a ligature, but I infer that he also uses it as a buried suture. He quotes from Nusbaum approvingly, "Catgut is without doubt Lister's greatest discovery," and states that he considers "the aseptic absorbable ligature as one of the greatest achievements of modern surgery." Dr. Ralph C. Larrabee of Boston in a recent article<sup>4</sup> gives an interesting review of the sterilization of catgut by boiling in alcohol. He quotes Lauenstein's investigations,<sup>5</sup> where, in a large series of cultures made for the purpose, he demonstrated quite a variety of micro-organisms as commonly present in catgut. Dr. Larrabee shows from his own experimental studies that boiling in 95 per cent. alcohol for one hour did not render the catgut sterile, and in each case he obtained cultures of a bacillus. Chemically, catgut contains water (23 per cent.) and fat (7.5 per cent.). By most of the recent processes of sterilization these substances must be removed. The remainder consists chiefly of collagen, which under the continued action of hot water is transformed into gelatin. Dr. Larrabee quotes the experiments of Saul, who found that if catgut was boiled in a 5 per cent. solution of carbolic acid in absolute alcohol, three hours were not enough to kill anthrax bacilli dried upon it. The addition of a small quantity of water gave much better results, since by using a 90 per cent. solution, instead of absolute alcohol, the bacilli were killed in ten minutes. Hofmeister has, however, found gut, after such boiling, contained staphylococci, which developed in proper culture media. As a result of Dr. Larrabee's investigations, he found that boiling the gut after Saul's method for fifteen minutes was sufficient to sterilize the smaller sizes, but, in forty experiments from the larger sizes,

<sup>4</sup> Boston Medical and Surgical Journal, Jan. 28, 1897.

<sup>5</sup> Archiv. f. klin. Chirurg., 50, 323, 1895.

boiled from fifteen to thirty minutes, he obtained six cultures. He therefore concludes that it is necessary, in order to be absolutely sure of sterility, to boil the smaller sizes thirty minutes, the medium forty-five minutes; the largest sizes are safer boiled one hour. "Catgut thus prepared deteriorates by age, and whether preserved wet or dry, a certain per cent. of the actual strength is certainly lost."

Dr. R. M. Pearce reports<sup>6</sup> a series of careful studies of sterilization of catgut with formaldehyde. This he applied by vaporizing small amounts of the 40 per cent. solution (formalin) into a glass chamber in which the catgut was exposed. In every experiment sterilization was satisfactory, but the gut became so brittle that it was ruined. He shows that the injury occurred largely from the moisture necessarily contained in the vaporized formalin. He found that the gas in a dry condition gave a much better result and this he recommends as a practical method of sterilization: "Nothing is required but a wide-mouthed jar, some paraform pastilles, a piece of wire gauze or open-meshed cloth and a wide-mouthed bottle. A dozen pastilles are put in the bottom of the jar and covered with a piece of wire gauze to prevent actual contact with the gut. The pastilles yield a sufficient amount of gas for complete sterilization."

Dr. A. Goldspohn<sup>7</sup> of Chicago has contributed an interesting article upon the preparation of catgut by formalin and boiling. From a careful review of the experimental studies of a number of reliable investigators and a series of his own he deduces the following: "These facts being known we must not depend on formalin to sterilize catgut but simply to harden it so that it may be boiled *ad maximum*. That this maximum boiling of twenty minutes may be possible it is necessary to remove all excess of formalin from the gut by prolonged washing in running water previously. But the vexatious question is now settled

<sup>6</sup> Boston Medical and Surgical Journal, April 19, 1898.

<sup>7</sup> Reprint, Chicago Medical Recorder, Vol. xiii.



that catgut can be certainly sterilized, for we can now boil it in water, the ideal menstruum, as long as the adherents of silk need or usually care to boil that, and the advantages of absorbable ligatures are too obvious to require further comment. However, there is one slight objection to catgut remaining, which arises from the ptomains which it may sometimes contain. On this subject Dr. Edmondo Orlandi in Turin published researches in 1895, and Professor Papfert of Giessen likewise toward the close of 1896. Both affirm the occurrence of slight or non-virulent suppuration limited to the immediate vicinity of the gut, not producing any systemic disturbance, and usually subsiding without any marked detriment locally. However, to avoid this objection partly, I am now having all catgut soaked in ether previously for forty-eight hours or more, to extract the fat, hoping also to get rid of some of the ptomains that may be present."

"My reasons for preferring catgut so prepared are, first and chiefly, because it stands the crucial culture tests that have been applied to it by its founders, which is not true of any former method, that of von Bergman not excepted, for Braatz cultivated anthrax spores of only moderate resistance in abundance from catgut prepared by that method. Secondly, because of the immense satisfaction to a surgeon derived from a knowledge of the supreme germicidal capacity of water boiling for twenty minutes. Thirdly, because this catgut is hardened enough to answer the purposes of chromicized catgut reasonably well without being too hard. From clinical observations my impression is that the smaller sizes hold from seven to ten days, while the larger sizes, as No. 6, used on pedicles, etc., hold for about fourteen days."

Formalin acts upon connective tissue in a way to change its ultimate cells and cement substance into a homogeneous mass of gelatinous character. Deformalized in running water for twenty-four hours and boiled loosely coiled in water, the gut or tendon swells immensely and shortens to about one-third its former

length. It is fibular, elastic, a homogeneous translucent mass. If wound tightly on a small test tube and boiled shrinkage does not take place, but the other changes ensue and the tensile strength is much lessened. If catgut thus heated remains in the tissues only as long as Dr. Goldspohn has determined, its durability is much too little to be trustworthy for many operative purposes.

In the present status of the question, the views of those who have, for a time at least, discarded the use of catgut as an unreliable suture material must be held to be justifiable.

In the New York *Medical Journal*, Feb. 18, 1897, is an interesting article upon slowly absorbable antiseptic catgut, prepared by a modification of Boeckmann's method, by C. W. Borden, M.D., U. S. Army. He believes that the chief merit of the method is in rendering the suture material much more slowly absorbable by boiling it for an hour and a half in a 1/500 solution of mercuric bichlorid in alcohol. This antiseptic catgut has given, in his experience, most excellent results. He does not think the small amount of bichlorid of importance in producing irritation or wound secretion, and that it is readily disposed of in the tissues without injury. He believes there is as little danger of bichlorid irritation as of iodoform poisoning from using the formalized catgut soaked in an alcoholic solution of iodoform, recommended by Senn.

Dr. Borden thinks that it is of manifest advantage to add his method of making an antiseptic suture to that of Boeckmann, which consists in sterilization by dry heat. He considers that the formalin method of Hofmeister produces a catgut not in any way equal to that which he recommends. He thinks kangaroo tendon has been greatly overrated and attempts to show by an experimental study of a wound that it is far less resistant to the tissues than has been usually considered, and singularly believes it conclusive by giving a photograph of a frayed end of a kangaroo

tendon suture emerging from the skin, "where it had been completely eaten through by leucocytes." Such examination teaches only the extraordinary rapidity with which the active proliferating processes supervene in the superficial layer of the skin, and this phenomenon has often been remarked upon in contradistinction to the processes which take place when the suture is buried in the tissues. The same process is observed uniformly, when the sutures are deeply taken through the mucous surfaces, as for example, the continuous over-and-over suture taken through the cervix of the uterus. Dr. Borden has taken the trouble to reproduce by micro-photographs the difference which followed the implantation of "unbichlorided kangaroo tendon and bichlorided catgut" in a septic wound, and shows that the tendon is less irritant than the catgut to disintegration changes. This should follow, if the bichlorid is of any value in preventing decomposition. He reports no attempt to show results where the catgut and kangaroo tendon, both of good quality and sterilized by the same method, have been aseptically buried in the same animal. Here, as I long since demonstrated, the contrast is most marked, and the results show that the tendon remains comparatively unchanged for a much longer period.

In the coaptation of the skin the subcuticular suture should be completely buried. The first end is fastened by a half knot, after the skin is penetrated. The stitch is taken parallel to the long axis of the wound, each succeeding stitch entering exactly opposite to the emergence of the previous one, and secured where the needle finally emerges through the skin by a half knot as at the beginning. This holds the edges in even, close coaptation. The ends of the suture are cut even with the skin, and slight tension in the long axis of the wound causes the ends to disappear below the surface (buried). It is then sealed with iodoform contractile collodion without drainage. The skin suture should be a fine one, and it is important to implant it only in the *deeper* layer



of the skin, subcuticular; otherwise the skin may proliferate before absorption ensues and superficial abscesses follow.

*Sterilization of tendon.*—A small portion of the dried tendon is soaked for a considerable period in a warm solution of bichlorid of mercury (1-1000). When well softened the tendons are easily separable. Each individual tendon is laid straight upon a wet sublimated towel and allowed to dry. When dry they are assorted. In this state they may be used with comparative safety. I have never been able to cultivate bacteria where culture tests have been made of tendons thus prepared. By reason of its histologic structure, as before explained, the tendon, when buried in the tissues, is much more slowly penetrated by the proliferative leucocytes than catgut. The effect of chromic acid upon the intercellular cement substance is extraordinary. It fixes it by a process of tanning and does not in any way interfere with its pliability, increases somewhat its tensile strength; causes it to absorb moisture more slowly and renders it much more resistant to the disintegrating influences, when buried in vitalized structures.

The tanning of certain grades of leather has been much improved by a somewhat similar use of chromic acid. The process is not only much shortened and cheapened, but the resultant product is very much more valuable. Recently, a large manufacturer showed me a goat skin thus tanned. It was not fine leather, but he said it would make a durable shoe, whereas under the old processes of tanning it would hardly be worth manufacturing. These methods are protected by patents and have already earned the owners over two millions of dollars. Chromic acid may be applied to the suture material in a strength which renders it unfit for use and makes it almost as slowly absorbable as silkworm gut. When properly chromicized, the suture should be of a light golden color and slightly translucent. It may be well preserved for an indefinite period in the dry state, but, as

Lord Lister long ago pointed out, preserved in light-colored boiled linseed oil, to which 5 per cent. of carbolic acid has been added, it seems to keep indefinitely, and for a certain period, I think, is improved by age. When only partially immersed, as in a bottle half full of oil, the tendon becomes sticky and is greatly damaged. If replaced, after being removed, in a wet state, in the carbolized oil, the water in the tendon forms a sort of emulsion which speedily ruins it. It may be preserved in many of the different ways which have been recommended for catgut, and so far as I am aware I have tried them all. By none, however, has the product remained permanently as reliable as by the method just given. Kangaroo tendon prepared as above is objected to because of the trouble in preparation and its cost; trouble in that the oily product is difficult to seal after having been bottled, and the oil must be removed from the tendon before using. However, the latter is easily effected by immersing the sutures, just previous to use, in a warm sublimate solution for half an hour. I consider the antiseptic quality resulting from the remaining bichlorid beneficial rather than otherwise.

Is such tendon trustworthy and assuredly aseptic? Infective wounds, from a variety of causes, will follow in a small percentage of cases in the practice of every surgeon, but it is his imperative duty to exercise every possible care to prevent it. The sterilization by heat is considered absolute, hence instruments, towels, gauze, etc., may be assumed non-infective. The certainty of such knowledge, so far as suture material goes, is of equal importance, and hence the oft-repeated injunction, "trust no sutures that you have not personally prepared." By culture tests I have assured myself that the tendon is sterile and each of the various processes in its preparation is always conducted under my personal supervision. The query most often made is "What shall I do with the unused tendon that has been soaked in the bichlorid solution?" Wrapped in a sterilized towel, it should be

sun-dried, and when thoroughly dry, replaced it in the carbolic oil for future use. Repeated treatment in this way leaves the tendon undamaged. For the last two years I have soaked the tendon for a considerable period in a solution of formalin, prior to its chromicization. This is a still further guarantee of disinfection.

Boiling in alcohol has been a favorite method with many surgeons for the disinfection of catgut. Sterilization of tendon may be effected by this method, but it renders it brittle, hard, and is much less satisfactory in its application. Dry heat is less damaging than by any other, except the above-mentioned chemical processes, and leaves a product more satisfactory than when boiled in alcohol. It is also perfectly easy of application by the simplest of all methods. There are two requisites, however, which are essential, the tendon must be entirely freed of the *oil* and *moisture*. A simple means of drying is to retain it for some hours in the sunshine, or in a warm oven. A coil of the dry tendon is placed in a large test-tube, with a dry cotton plug; over the end of the tube a rubber cap is securely tied. This is put in the sterilizer as long as it may be deemed desirable and thereby is known to be trustworthy. If only a very slight degree of moisture remains in the tendon, the resultant will be a compact mass of ruined material.

Tendon will bear repeated heating in this way with comparatively little damage, and it may be recommended as a safe means of assurance to the surgeon that any possible subsequent infection of the wound is not caused by his suture material. Kangaroo tendon sutures should be obtained at a cost of ten dollars per hundred, and so great has been the demand for it that I have had it prepared in quantity, under my personal supervision, for general use, which I fully believe is absolutely trustworthy and reliable. These sutures are coming into general use. I am constantly in receipt of letters reporting the great satisfaction following their employment; I have already quoted



Dr. Coley. Dr. F. W. Longyear of Detroit says: "My experience has been entirely with this material, and has extended over a period of more than four and one-half years, during which time I have used it for both ligature and suture in fifty-seven cases of celiotomy, with and without drainage, and I have yet to see my first case of post-operative hernia where this material was employed."

Kangaroo tendon ligatures, ten or twelve inches in length, should cost less, since in the preparation of sutures which are long, fine, smooth and even, the larger part of the gross material is rejected.

It is quite difficult to obtain really fine sutures, and much placed upon the market is not of first quality. I have written the above description in careful detail, since there can be no question but that the use of the buried animal suture marks the greatest advance in the development of aseptic surgery. When applied in closing the abdominal wound by suturing the different layers independently, the skin also closed by a subcuticular continuous suture and the wound sealed with iodoform collodion, hernia is practically avoided. In over eight hundred aseptic laparotomies thus closed I have had but once subsequent hernia, and that in an extremely thin abdominal wall after the removal of a large uterine myoma. The cure of hernia by any of the so-called modern methods is dependent absolutely upon the use of buried sutures in closing the neck of the sac, reinforcing the weakened structures and the reconstruction of the obliquity of the inguinal canal, and it was for this very purpose I first employed animal sutures in 1870. With all the emphasis of an earnest conviction, I commend to every aseptic surgeon familiarization with the methods of wound closure by means of buried absorbable sutures, preferably tendon, and not alone predict their general adoption, but believe that in importance they hold the first place in the technic of modern aseptic wound treatment.

180 Commonwealth Avenue.









